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# Farnell

TRANSISTORISED
R.F. MILLIVOLTMETER
TYPE TM6.

## INSTRUCTION BOOK

FARNELL INSTRUMENTS LIMITED

# TRANSISTORISED
# R.F. MILLIVOLTMETER
# TYPE TM6.

FARNELL INSTRUMENTS LIMITED,
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0937 3541/6.

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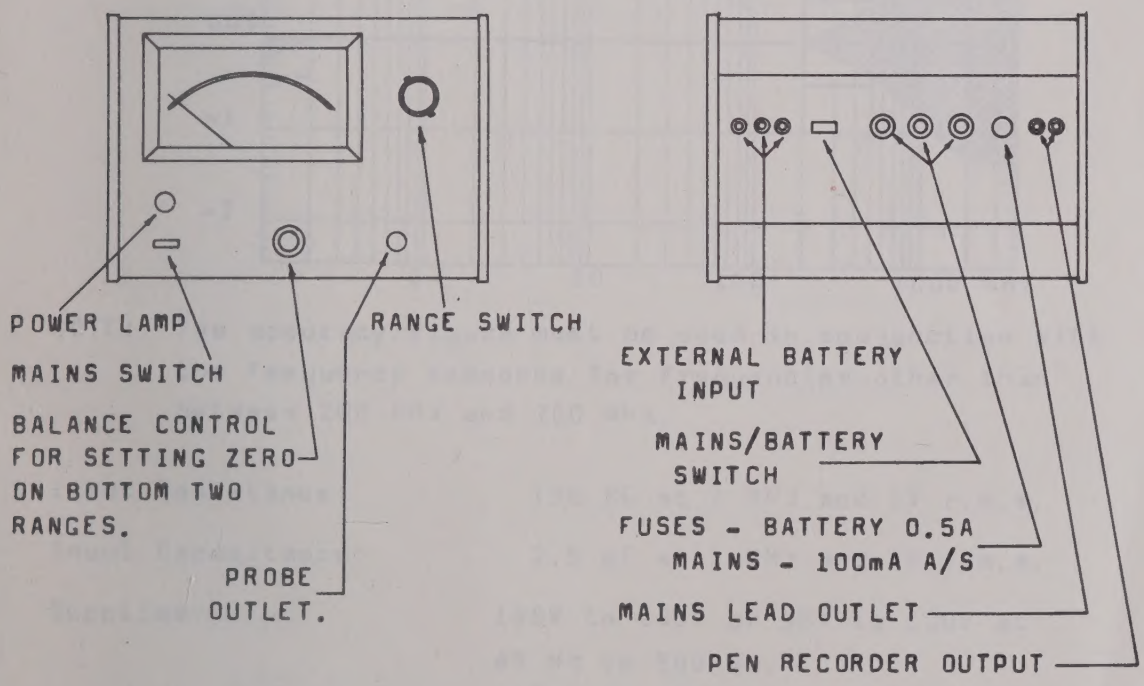
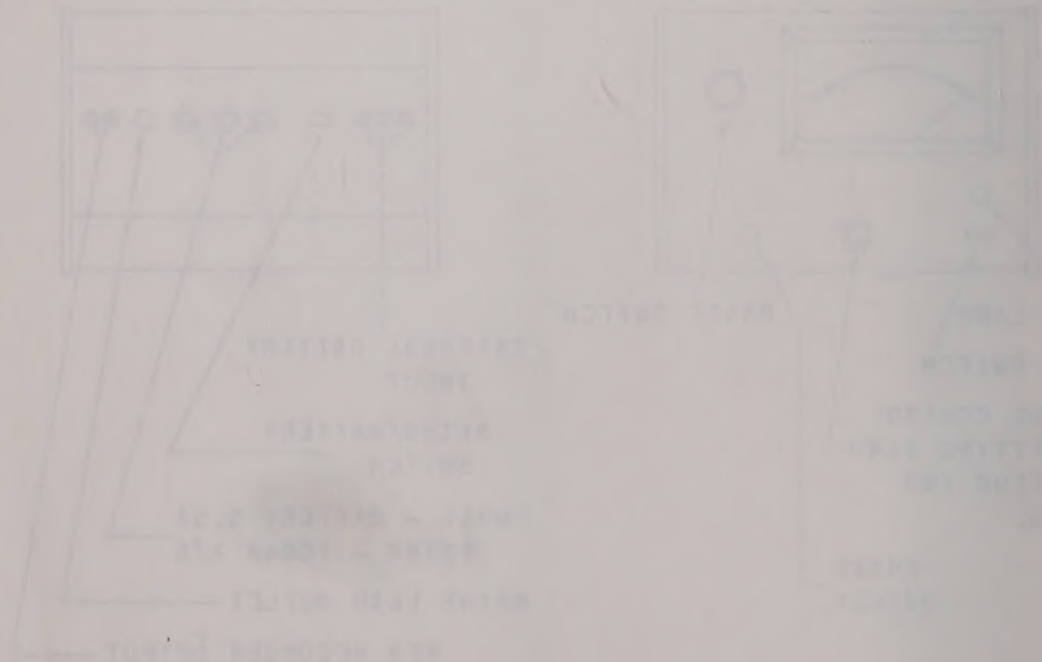
The TM-6 R.F. Millivoltmeter is a general purpose millivoltmeter of high sensitivity. The frequency range is 50 KHz to 1500 MHz with full scale deflection from 1mV r.m.s. to 3V r.m.s.

The readings on the 30 mV and lower ranges are very close to true r.m.s. This also applies to measurements of 3V and less when used with the X100 multiplier.

The full wave diode probe configuration reduces errors due to non-symmetry of the signal being measured.

The instrument is small in size, due to the use made of linear integrated circuits. All circuits including probe, are solid state for better reliability.





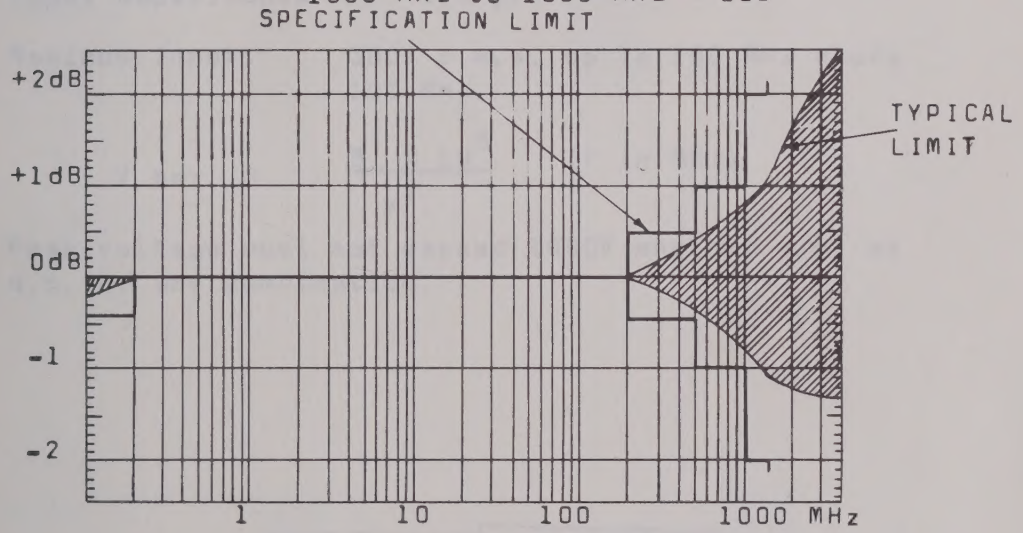
**Voltage Range:** 1 mV r.m.s. full scale to 3V r.m.s. full scale. Max. input 8V r.m.s. Max. d.c. to be applied to probe is 300V.

**Frequency Range:** 50 KHz to 1500 MHz giving a useful indication to 3000 MHz.

**Accuracy:** (10°C - 40°C)
1 mV and 3mV ranges ± 5% of full scale.
Linearity ± 5% F.S.D.
10mV range and higher ± 3% of full scale.
Linearity ± 2% of full scale.
(200 KHz to 200 MHz.)

**Frequency Response:** With respect to 100 MHz:

50 KHz to 200 KHz +0, -0.4 dB
200 MHz to 500 MHz ± 0.5 dB
500 MHz to 1000 MHz ± 1dB.
1000 MHz to 1500 MHz ± 2dB




NOTE: The accuracy figure must be used in conjunction with the frequency response for frequencies other than between 200 KHz and 200 MHz.

**Input Resistance:** 150 KΩ at 1 MHz and 1V r.m.s.

**Input Capacitance:** 2.5 pF at 1 MHz and 1V r.m.s.

**Supplies:** 190V to 260V or 95V to 130V at 45 Hz to 500 Hz.
External batteries +18V to+24V & -18V to -24V.

**Dimensions:**

| Height With Feet | Width | Depth (including handles). |
|---|---|---|
| $6\frac{3}{8}$ | $8\frac{5}{8}$ | $9\frac{7}{8}$ |
| 162 m.m. | 218 m.m. | 251 m.m. |

1. Earthing Clip - TM6/1.

2. 100 : 1 Multiplier (500 KHz to 500 MHz) - TM6/2.

Accuracy:

0.5 MHz to 20 MHz : ± 0.3 dB.
20 MHz to 100 MHz : ± 0.1dB.
100 MHz to 200 MHz ± 0.3 dB.
200 MHz to 300 MHz ± 0.7 dB.
300 MHz to 500 MHz ± 1.5 dB.

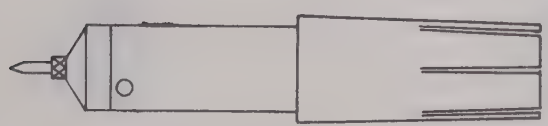
Input resistance 20 MΩ at 1 MHz.
1 MΩ at 50 MHz.
100 KΩ at 300 MHz.

Input Capacitance 2.5 pF.

Maximum Input: 300V r.m.s. up to 100 MHz above 100 MHz.

$$V_{max} = \frac{3 \times 10^6}{f^2} \quad (f \text{ in MHz})$$

Peak voltage must not exceed 1000V whether a.c. or d.c. or any combination.



100:1 MULTIPLIER - TM6/2.

(OPTIONAL)

3. Coaxial 'T' connector - TM6/3.

Return loss ≤ 20 dB at 1500 MHz when terminated in 50Ω, with TM.6 probe plugged in side entry.

4. Probe to type 'N' adaptor TM6/4 (terminated) - 1/4W, 50Ω.

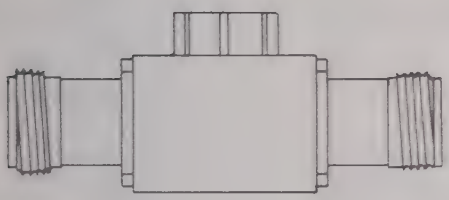
Return loss: <- 25 dB to 500 MHz.

<- 20 dB to 900 MHz.

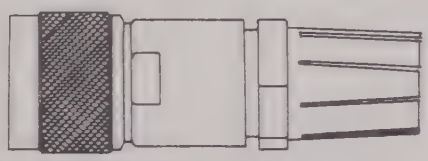
5. Probe to type 'N' adaptor type TM6/5 (unterminated) as above but without load.

6. 50Ω load, $^{1}/_{4}$W - TM6/6, type 'N' plug termination.

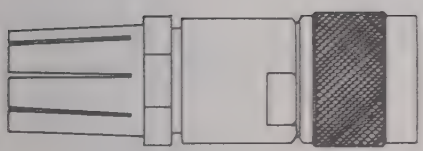
Return loss <-25 dB to 1500 MHz.



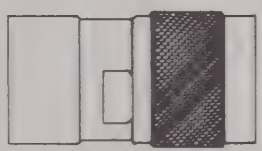
COAXIAL 'T' CONNECTOR
- TM6/3.



PROBE TO TYPE 'N' ADAPTOR
- TM6/4.



PROBE TO TYPE 'N' ADAPTOR
- TM6/5.



50Ω LOAD TYPE 'N'
- TM6/6.

1. Installation.

Fit mains plug: Line-Brown, Neutral-Blue and earth Yellow/Green.

Check that mains taps are set for the required mains voltage and that the correct fuse is fitted:

100mA for 190-260V input.
200mA for 95-130V input.

Check that the mains/battery switch is in the 'MAINS' position.

Switch on and allow at least 5 minutes warm-up time. Best accuracy is obtained after 20 minutes.

2. Operation.

The instrument may now be used to measure voltages up to 3V r.m.s. For measurement of low levels, up to 10mV r.m.s., it is necessary to zero the meter by means of the balance control.

Care should be taken when zeroing the 1mV range as the balance control is quite coarse on this range and there is a time delay before the meter follows the adjustment. This is due to the fact that the thermal e.m.f. produced by the diodes is of a greater magnitude than the detected voltage due to the signal.

The sensitivity of the probe to spurious pick-up, especially mains-bourne spikes, is very high, and it is advisable to use the adaptors to minimise this. To ensure best balance on the 1mV range, it is advisable to use a terminated adaptor to earth the probe tip. DO NOT RELY ON TOUCHING THE PROBE TIP TO THE CHASSIS.

To obtain the exact zero setting, it is necessary to first evaluate the typical peak-to-peak swing of the pointer by offsetting the zero. Then reduce the setting slowly until the pointer dwells on the electrical end stop (just below zero) for about 50% of the time. The peak deflection should correspond to half the peak-to-peak figure (linear scale) previously recorded. It may be necessary to readjust the zero for use on the 3mV range.

Random noise $\pm$ 2 small divisions on the 0-10 scale.

Impulse pick-up $\pm$ 7 small divisions on the 0-10 scale.

(The impulse figures may vary according to the electrical environment in which the instrument is used).

The probe consists of two diodes in a fullwave configuration which produce d.c. levels, on the two output leads, proportional to the positive and negative peaks of the waveform being measured.

After filtering, these two d.c. levels are applied to PR1 and PR2, photo-resistors which are made to conduct in an antiphase sequence by the photo-emitting diodes D12 and D13, producing a square-wave of peak to peak amplitude equal to the potential difference between the two d.c. levels.

To allow the diodes to operate at levels as low as 1mV r.m.s. it is necessary to run them at a very low current. This necessitates a very high input impedance to the first stage of the a.c. amplifier.

This is realised by the use of two f.e.t.'s (VT1 and VT2) as a long-tailed-pair pre-amplifier to the first integrated operational amplifier, OA1.

The d.c. feedback ensures a d.c. gain of unity for thermal stability, while the a.c. gain is controlled by R16 and the resistor selected by the range switch SA1.

The second amplifier is identical to the first with the exception of the high impedance pre-amplifier.

The output of the second a.c. amplifier is d.c. restored in a synchronous mode by f.e.t. VT.3 and fed into the lag circuit involving OA3. There is a preset resistor associated with each range, at the input of this stage, to allow calibration.

The d.c. output from this stage is fed into a diode function generator, incorporated in the feedback reference of OA5, which corrects for the diode law on all ranges except the 1mV range.

The meter is driven directly from the output of this stage.

The oscillator, controlling the operation of the photo-chopper, consists of an astable multivibrator circuit incorporating OA4.

The power supplies of +15V and -15V are obtained by means of a centre-tapped transformer and two fullwave rectifiers D4, D5, D6 and D7, and regulated by the series regulators VT. 6 and VT7.

The transformer primaries are connected in series for 190-260V operation and in parallel for 95-130V operation.

Two external batteries of 18-24V each may be used instead of the mains supply.

| | | | |
|---|---|---|---|
| R1 | Resistor 56Ω | NOMINAL | MULLARD MR30. |
| R2 | Resistor 22M | ±10% | DUBILIER BTT. |
| R3 | Resistor 22M | ±10% | DUBILIER BTT. |
| R4 | Resistor 220K | ± 2% | MULLARD MR30. |
| R5 | Resistor 220K | ± 2% | MULLARD MR30. |
| R6 | Resistor 100M | ±10% | DUBILIER BTT. |
| R7 | Resistor 10K | ± 2% | MULLARD MR30. |
| R8 | Resistor 12K | ± 2% | MULLARD MR30. |
| R9 | Resistor 10K | ± 2% | MULLARD MR30. |
| R10 | Resistor 100K | ± 2% | MULLARD MR30. |
| R11 | Resistor 1.8K | ± 2% | MULLARD MR30. |
| R12 | Resistor 10K | ± 2% | MULLARD MR30. |
| R13 | Resistor 47K | ±2% | MULLARD MR30. |
| R14 | Resistor 100K | ± 2% | MULLARD MR30. |
| R15 | Resistor 1.5K | ± 2% | MULLARD MR30. |
| R16 | Resistor 1M | ± 2% | MULLARD MR30. |
| R17 | Resistor 220K | ± 2% | MULLARD MR30. |
| R18 | Resistor 820K | ± 2% | MULLARD MR30. |
| R19 | Resistor 1.2K | ± 2% | MULLARD MR30. |
| R21 | Resistor 47K | ± 2% | MULLARD MR30. |
| R22 | Resistor 1.8K | ± 2% | MULLARD MR30. |
| R23 | Resistor 10K | ± 2% | MULLARD MR30. |
| R24 | Resistor 1.5K | ± 2% | MULLARD MR30. |
| R25 | Resistor 100K | ± 2% | MULLARD MR30. |
| R26 | Resistor 39K | ± 2% | MULLARD MR30. |
| R27 | Resistor 100K | ± 2% | MULLARD MR30. |
| R28 | Resistor 560K | ± 2% | MULLARD MR30. |
| R29 | Resistor 1K | ± 2% | MULLARD MR30. |
| R30 | Resistor 1M | ± 2% | MULLARD MR30. |
| R31 | Resistor 1.2M | ± 1% ± 100 P.P.M./°C. | WELWYN 4013. |
| R32 | Resistor 4.7M | ± 1% ± 100 P.P.M./°C. | WELWYN 4013. |
| R34 | Resistor 1K | ± 2% | MULLARD MR30. |
| R35 | Resistor 1K | ± 2% | MULLARD MR30. |
| R36 | Resistor 270K | ± 2% | MULLARD MR30. |
| R37 | Resistor 100K | ± 2% | MULLARD MR30. |
| R38 | Resistor 10K | ± 2% | MULLARD MR30. |
| R39 | Resistor 10K | ± 2% | MULLARD MR30. |
| R40 | Resistor 180K | ± 2% | MULLARD MR30. |
| R41 | Resistor 5.6K | ± 2% | MULLARD MR30. |
| R42 | Resistor 2.2M | ± 5% | DUBILIER BTT. |
| R45 | Resistor 5.6K | ± 2% | MULLARD MR30. |
| R46 | Resistor 12K | ± 2% | MULLARD MR30. |
| R47 | Resistor 22K | ± 2% | MULLARD MR30. |
| R48 | Resistor 22K | ± 2% | MULLARD MR30. |
| R49 | Resistor 680Ω | ± 2% | MULLARD MR30. |

| | | |
|---|---|---|
| R50 | Resistor 1K ± 2% | MULLARD MR30. |
| R51 | Resistor 82[illegible] ± 2% | MULLARD MR30. |
| R52 | Resistor 180K ± 2% | MULLARD MR30. |
| R54 | Resistor 8.[illegible]K ± 2% | MULLARD MR30. |
| R55 | Resistor 15K ± 2% | MULLARD MR30. |
| R56 | Resistor 1K ± 2% | MULLARD MR30. |
| R57 | Resistor 220Ω ± 5% | ELECTROSIL TR8. |
| R58 | Resistor 8.2K ± 2% | MULLARD MR30. |
| R59 | Resistor 220Ω ± 5% | ELECTROSIL TR8. |
| R60 | Resistor 470Ω ± 2% | MULLARD MR30. |
| R61 | Resistor 180Ω ± 2% | MULLARD MR30. |
| R62 | Resistor 120Ω ± 2% | MULLARD MR30. |
| R63 | Resistor 150Ω ± 2% | MULLARD MR30. |
| R64 | Resistor 2.2K ± 2% | MULLARD MR30. |
| R65 | Resistor 47K ± 2% | MULLARD MR30. |
| R66 | Resistor 270K ± 2% | MULLARD MR30. |
| R67 | Resistor 68K ± 2% | MULLARD MR30. |
| R68 | Resistor 22K ± 2% | MULLARD MR30. |
| R69 | Resistor 56K ± 2% | MULLARD MR30. |
| R70 | Resistor 100K ± 2% | MULLARD MR30. |
| R71 | Resistor 5.6K ± 2% | MULLARD MR30. |
| R72 | Resistor 1K ± 2% | MULLARD MR30. |
| R73 | Resistor 47K ± 2% | MULLARD MR30. |
| R74 | Resistor 47K ± 2% | MULLARD MR30. |
| R75 | Resistor 47K ± 2% | MULLARD MR30. |
| R77 | Resistor 100K ± 2% | MULLARD MR30. |
| R78 | Resistor 2.2K ± 2% | MULLARD MR30. |
| R79 | Resistor 2.2K ± 2% | MULLARD MR30. |
| R80 | Resistor 180K ± 2% | MULLARD MR30. |
| R81 | Resistor 180Ω ± 2% | MULLARD MR30. |
| R82 | Resistor 4.7K ± 5% | WELWYN W21. |
| R83 | Resistor 4.7K ± 5% | WELWYN W21. |
| R84 | Resistor 390K ± 2% | MULLARD MR30. |
| R85 | Resistor 1K ± 2% | MULLARD MR30. |
| R86 | - R90 SOT | MULLARD MR30. |

| | | | |
|---|---|---|---|
| C1 | Capacitor 1000p | 500V | ERIE 861/K7004 |
| C2 | Capacitor 1000p | 500V | ERIE 861/K7004 |
| C3 | Capacitor 1000p | 500V | ERIE 861/K7004 |
| C4 | Capacitor 0.1µ | 30V | ERIE 811/T/30 |
| C5 | Capacitor 0.1µ | 30V | ERIE 811/T/30 |
| C6 | Capacitor 4,700p | 500V | ERIE 801/K7004 |
| C7 | Capacitor 4,700p | 500V | ERIE 801/K7004 |
| C8 | Capacitor 10µ | 15V | I.T.T. TAG 10/15 |
| C9 | Capacitor 220p | 500V | ERIE 831/K120051 |
| C10 | Capacitor 47p | 500V | ERIE 801/N470 |
| C11 | Capacitor 2000µ | 16V | MULLARD C431 8R/E2000 |
| C12 | Capacitor 0.1µ | 30V | ERIE 811/T/30 |

| | | | | |
|---|---|---|---|---|
| C13 | Capacitor | 2000µ | 16V | MULLARD C431BR/E2000 |
| C14 | Capacitor | 4,700p | 500V | ERIE 801/K7004 |
| C15 | Capacitor | 220p | 500V | ERIE 831/K120051 |
| C16 | Capacitor | 10µ | 15V | I.T.T. TAG 10/15 |
| C17 | Capacitor | 47p | 500V | ERIE 801/N470 |
| C18 | Capacitor | 0.1µ | 30V | ERIE 811/T/30 |
| C19 | Capacitor | 0.1µ | 25V | ERIE 811/T/25 |
| C22 | Capacitor | 500µ | 40V | MULLARD C431/BR/G500 |
| C23 | Capacitor | 500µ | 40V | MULLARD C431/BR/G500 |
| C24 | Capacitor | 1µ | 160V | WIMA TFM |
| C25 | Capacitor | 4,700p | 500V | ERIE 801/K7004 |
| C26 | Capacitor | 220p | 500V | ERIE 831/K120051 |

| | | |
|---|---|---|
| D1 | Diode | A.E.I. CG91AH |
| D2 | Diode | A.E.I. CG91AH |
| D3 | Diode | Transitron IN695 |
| D4 | Diode | Motorola IN4003 |
| D5 | Diode | Motorola IN4003 |
| D6 | Diode | Motorola IN4003 |
| D7 | Diode | Motorola IN4003 |
| D8 | Diode | S.T.C. Zener ZF5.6 |
| D9 | Diode | S.T.C. Zener ZF5.6 |
| D10 | Diode | Texas Zener IS7150A |
| D11 | Diode | Texas Zener IS7150A |
| D12 | Diode | Fairchild Light Emitter FLD100 |
| D13 | Diode | Fairchild Light Emitter FLD100 |
| D14 | Diode | Texas IN914 |
| D15 | Diode | Texas IN914 |
| D16 | Diode | Texas IN914 |
| D17 | Diode | Texas IN914 |
| D18 | Diode | Texas IN914 |
| D19 | Diode | Motorola IN4003 |
| D20 | Diode | Motorola IN4003 |
| D21 | Diode | Texas IN914 |

| | | |
|---|---|---|
| OA1 | Integrated Circuit | SGS µA 709 |
| OA2 | Integrated Circuit | SGS µA 709 |
| OA3 | Integrated Circuit | SGS µA 741 |
| OA4 | Integrated Circuit | SGS µA 741 |
| OA5 | Integrated Circuit | SGS µA 741 |

| | | |
|---|---|---|
| VT1)<br>VT2) | Transistor | Texas matched pair F.E.T.'s TIS70 |
| VT3 | Transistor | Texas F.E.T. 2N3819 |
| VT4 | Transistor | Ferranti ZTX502 |
| VT5 | Transistor | Ferranti ZTX303 |
| VT6 | Transistor | Motorola MJE520 |
| VT7 | Transistor | Motorola MJE370 |
| VT8 | Transistor | Ferranti ZTX502 |
| VT9 | Transistor | Ferranti ZTX502 |

| | | | |
|---|---|---|---|
| RV1 | Potentiometer | 5K | Plessey Type M |
| RV2 | Potentiometer | 220K | Plessey MP |
| RV3 | Potentiometer | 220K | Plessey MP |
| RV4 | Potentiometer | 220K | Plessey MP |
| RV5 | Potentiometer | 220K | Plessey MP |
| RV6 | Potentiometer | 220K | Plessey MP |
| RV7 | Potentiometer | 220K | Plessey MP |
| RV8 | Potentiometer | 220K | Plessey MP |
| RV9 | Potentiometer | 220K | Plessey MP |
| RV10 | Potentiometer | 22K | Plessey MP |
| RV11 | Potentiometer | 10K | Plessey MP |
| RV12 | Potentiometer | 22K | Plessey MP |
| RV13 | Potentiometer | 56K | Plessey MP |
| RV14 | Potentiometer | 56K | Plessey MP |
| RV15 | Potentiometer | 56K | Plessey MP |

| | | |
|---|---|---|
| PR1 | Photocell | Teknis VT21M |
| PR2 | Photocell | Teknis VT21M |

| | | |
|---|---|---|
| F1 | Fuse | 100mA A/S Beswick for 240V or 200mA A/S for 120V. |
| F2 | Fuse | 500mA Beswick. |
| F3 | Fuse | 500mA Beswick. |

| | | |
|---|---|---|
| LP1 | Lamp 24V Red | Guest International LS7-GT |

| | | |
|---|---|---|
| M1 | Meter 100µA movement | Sifam Clarity Focus<br>SP3739/2, SP3740/2 |

Input frequency = 100MHz.

1. Set range to 100mV & adjust RV6 for full-scale reading, RV15 for 1/3 full-scale and RV12 for zero on the 30mV range. (R88 is selected to give zero on 100mV range when RV12 has been adjusted to give zero on 30mV range).

   Adjust RV5 for full-scale and RV14 for 1/3 full-scale on the 30mV range.

   Re-check to zero settings.

2. Adjust balance control for zero on the 1mV range and adjust RV2 for full-scale setting.

3. Set 3mV range zero point with RV10 and adjust RV3 for full-scale setting. Repeat until both settings are correct.

4. Set full-scale on the 10mV range with RV4 and 1/3 full-scale with RV3. Repeat until both readings are correct. Adjust zero point with RV11. Re-check 1/3 full-scale.

5. Check 80mV and 100mV full-scale, 1/3 full-scale and zero settings.

6. Set full-scale on the 3V range with RV9 and 1/3 full-scale with RV18.

7. Set full-scale on the 1V range with RV8 and 1/3 full-scale with RV17.

8. Set full-scale on the 300mV range with RV7 and 1/3 full-scale with RV16.

9. Select a value of R89 for zero on the 300mV range and R90 for zero on the 1V range.

N.B. RE-CALIBRATION SHOULD NOT REQUIRE REPLACEMENT OF THE SELECTED RESISTORS.

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ERRATA AND ADDENDA

ALTERNATIVE COMPONENTS TO THOSE LISTED ON CIRCUIT DIAGRAM MAY BE USED IN THE EVENT OF SUPPLY DIFFICULTIES. MAJOR CHANGES TO THE DESIGN OR MANUAL ARE LISTED BELOW:-

| | | |

DRAWING No. 2 - 5757

USED ON

| | | |

FARNELL INSTRUMENTS LIMITED · SANDBECK WAY · WETHERBY · YORKSHIRE LS22 4DH · TELEPHONE 0937 3541

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